

**Universal Counter-Timers**

**9902 and 9906**

**Operators Handbook**

**RACAL**  
The Electronics Group

**OPERATORS HANDBOOK  
FOR  
UNIVERSAL COUNTER-TIMERS  
9902 and 9906.**

**RACAL-DANA INSTRUMENTS LIMITED**

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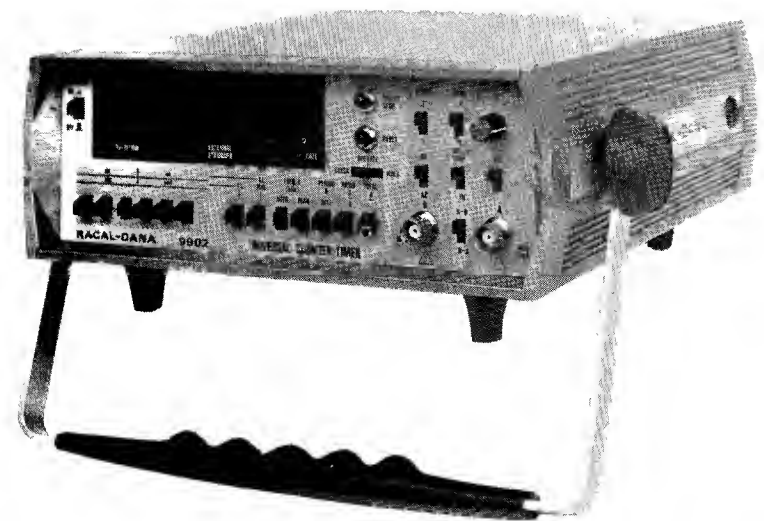
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Universal Counter Timers  
9902 and 9906

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## OPERATING INSTRUCTIONS

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TECHNICAL SPECIFICATION

NOTE: The data refers equally to 9902 and 9906 except where indicated otherwise.

1. GENERAL

Model 9902 is a 6 digit 50 MHz Autoranging Universal Counter Timer.

Model 9906 is an 8 digit 200 MHz Manual version with consequent extended ranges on all measuring functions.

2. MEASURING FUNCTIONS

Modes of operation:	<u>9902:</u>	Frequency (Manual), Frequency (Autoranging), Single and Multiple Period, Single and Multiple Ratio, Single and Double Line Time Interval, Single and Double Line Time Interval Averaging; Totalizing.
	<u>9906:</u>	Frequency (Manual), Single and Multiple Period, Single and Multiple Ratio, Single and Double Line Time Interval, Single and Double Line Time Interval Averaging, Totalizing.

3. DISPLAY

Format:	<u>9902:</u>	Six digit in-line, l.e.d. seven segment display. Decimal point automatically positioned.
	<u>9906:</u>	Eight digit in-line, l.e.d. seven segment display. Decimal point automatically positioned.
Latch:		The display is latched for Frequency, Period and Ratio measurement and automatically unlatched in all other modes.
LED indicators:		Refer to the descriptions on page 3-4.

Display Time:	Gate time plus 0.15s in Frequency, Period and Ratio modes.  1.5s in other modes. A switched hold position is provided.
Measurement Check:	Counter reads 1 MHz.
Segment Check:	Sets display l.e.d.'s to 8 when Check and Reset selected.
Reset:	Manual by push-button, or automatic.

#### CHANNEL A INPUT - A.C. COUPLED

Frequency range:	<u>9902:</u> 10 Hz to 50 MHz <u>9906:</u> 10 Hz to 200 MHz
Sensitivity:	<u>9902:</u> 10mV r.m.s. (variable by sensitivity control). <u>9906:</u> 10mV r.m.s. to 150 MHz, 50mV r.m.s. to 200 MHz (variable by sensitivity control).
Maximum signal level:	250V r.m.s. up to 10 kHz 50V r.m.s. up to 100 kHz 10V r.m.s. above 100 kHz
Maximum input level:	The d.c. level + peak signal level must not exceed 400V over the full frequency range.
Input impedance:	1M $\Omega$ in parallel with approximately 25pF falling to 100k $\Omega$ at 4V r.m.s. with sensitivity control in 10mV position.

#### CHANNEL B INPUT - AC COUPLED

Frequency range:	<u>9902:</u> 100Hz - 10 MHz <u>9906:</u> 10 Hz - 10 MHz
Sensitivity:	100mV r.m.s.

#### CHANNEL B INPUT - AC COUPLED (Continued)

Maximum Signal Level:	<u>9902:</u> 70V r.m.s. up to 8MHz, decreasing to 60V r.m.s. at 10MHz. <u>9906:</u> 100V r.m.s. up to 1MHz, decreasing to 36V r.m.s. at 10MHz.
Maximum Input Level:	The d.c. level + peak signal level must not exceed 100V (9902) or 200V (9906) over the full frequency range.
Input Impedance:	<u>9902:</u> 10k $\Omega$ in parallel with 25pF, approx. <u>9906:</u> 1M $\Omega$ in parallel with 25pF, approx.
Pulse duration:	25 ns minimum at trigger points.
Delay IN:	The Stop channel is delayed from triggering by approximately 10 ms after triggering by the Start signal. (DELAY switch set to IN).

#### CHANNELS A & B - D.C. COUPLED

Frequency range:	DC to 20MHz on A channel. DC to 10MHz on B channel.
Sensitivity:	$\pm 0.15V$ about +0.8V nominal.
Maximum input level:	<u>9902:</u> $\pm 100V$ up to 8MHz, decreasing to +43V at 20MHz (signal plus d.c.level = 100V maximum over full frequency range). <u>9906:</u> $\pm 140V$ up to 1MHz, decreasing to +28V at 20MHz (signal plus d.c.level = 140V maximum over full frequency range).
Delay IN:	The Stop channel is delayed from triggering by approximately 10 ms after triggering by the Start signal. (DELAY switch set to IN).
Pulse duration:	25 ns minimum at trigger points.
Input impedance:	<u>9902:</u> 10k $\Omega$ in parallel with 25pF approximately. <u>9906:</u> 1M $\Omega$ in parallel with 25pF approximately, falling to 100k $\Omega$ at $\pm 5V$ .

#### 4. FREQUENCY MEASUREMENT

Input:	Channel A
Frequency range:	<u>9902:</u> DC to 50 MHz (direct)
	<u>9906:</u> HF a.c. coupled: 10 Hz - 30 MHz HF d.c. coupled: d.c. - 20 MHz VHF: 10 MHz - 200 MHz (prescaled by 4).
Coupling:	AC or DC
Gate times:	<u>9902:</u> Manual: 1 ms to 100s in decade steps  Automatic: (9902 only) Gate times up to 1s are selected automatically to avoid overspill. A 1 kHz hysteresis avoids un-desirable range changing of small frequency deviations.  <u>9906:</u> Manual: HF - 1 ms to 100s in decade steps. VHF - 4 ms to 400s in decade steps.
Accuracy:	$\pm 1$ count $\pm$ frequency standard accuracy.

#### 5. SINGLE AND MULTIPLE PERIOD MEASUREMENT

Input channel:	Channel A
Range:	<u>9902:</u> 1 $\mu$ s to 1s <u>9906:</u> 1 $\mu$ s to 100s
Clock unit:	1 $\mu$ s
Coupling:	AC or DC
Periods averaged:	1 to 10 <sup>5</sup> in decade multiples

Accuracy:  $\pm 0.3\%$   $\pm$  freq. std. accuracy  
Number of periods averaged  $\pm 1$  count  
(at 50 mV r.m.s. ac input with 40 dB S/N ratio).

Bandwidth: Automatically reduced to 10 MHz (3 dB) when on AC with Period selected.

#### 6. TIME INTERVAL SINGLE AND DOUBLE LINE

Input channel:	Single Line: Channel B Double Line: Start Channel B: Stop Channel A
Time range:	<u>9902:</u> 100 ns to 10 <sup>4</sup> s (2.8 hours approximately) <u>9906:</u> 100 ns to 10 <sup>6</sup> s (280 hours approximately)
Clock	100 ns to 10 ms
Coupling:	DC on A channel AC or DC on B channel
Start/Stop signals:	Electric or contact.
Manual start/stop:	By single push button on front panel.
Trigger slope selection:	Electric. Positive or negative slopes can be selected on both Start and Stop signals.
Accuracy:	$\pm 1$ count $\pm$ trigger error * $\pm$ frequency std accuracy.

#### 7. TIME INTERVAL AVERAGING SINGLE AND DOUBLE LINE

Input channel:	Single Line: Channel B Double Line: Start Channel B: Stop Channel A
Time range:	<u>9902:</u> 150 ns to 0.1s <u>9906:</u> 150 ns to 10s
Dead time between intervals:	150 ns minimum
Clock unit:	100 ns
Time intervals averaged:	1 to 10 <sup>5</sup> in decade multiples.

\* For trigger error see page Tech. Spec. (6).

Accuracy:  $\pm$  Frequency standard accuracy  $\pm$  system error  
 $\pm$  averaging error

System error: 10 ns maximum per input channel. This is the difference in delays between start and stop signals and can be minimised by matching externally. Signal under measurement must not be harmonically related to the internal clock.

Averaging Error:  $\frac{\text{Trigger error} + 100 \text{ ns}}{\sqrt{(\text{Intervals Averaged})}}$   
 (in ns)

Trigger Error:  $\frac{10}{2 \times \text{Signal Slope at trigger point (V/us)}}$   
 (in ns)

8. RATIO

Higher frequency input: Channel A

Lower frequency input: Channel B

Frequency range (Channel A):  
 9902: DC to 50 MHz  
 9906: DC to 30 MHz

Frequency range (Channel B): DC to 10 MHz

Accuracy:  $\pm 1 \text{ count} \pm$  trigger error on channel B (see above)

Reads:  $\frac{\text{Frequency A} \times n}{\text{Frequency B}}$

Multiplier n: 1 to  $10^5$  in decade multiples.

9. TOTALIZING

Input channel: Channel A (DC to 10 MHz)

Maximum rate:  $10^7$  events per second.

Pulse width: 50 ns minimum at trigger points.

Prescaling: Events can be prescaled in decade multiples (n) from 1 to  $10^5$ .

Reads:  $\frac{\text{Number of input events} + 1 \text{ count}}{n} - 0$

Manual start/stop: Single push button on front panel.

Delay IN: With Delay switch at IN, both channels are delayed by approximately 10 ms from triggering (useful for contact operation).

Electrical start/stop: By electrical signal applied to Channel B.

FREQUENCY STANDARD

Frequency: 5 MHz

Type: Refer to Options 04A, 04B and 04C on page Tech. Spec. (9). Normally 04C will be fitted.

Frequency standard output: 1 MHz rectangular waveform at rear panel BNC socket. When using internal standard the output level is TTL compatible (approximately 600 mV p-p into 50  $\Omega$ )

EXTERNAL STANDARD

Frequency: 1 MHz

Input socket: Applied to channel B input socket and provides external standard for Frequency and Period measurement only.

EXTERNAL SIGNALS

Data outputs: Eight digits with overflow and decimal points in serial BCD form at standard TTL levels. Refer to Table 1.

Other outputs: Function and timebase data. Refer to Tables 2 and 3.

Inputs: Reset and print hold.

Accessories: See Option 01.



## POWER REQUIREMENTS

Voltage ranges (o.c.): Appropriate transformer connections allow six pairs of voltage ranges to be selected. A rear panel switch selects either the upper or lower range of each pair.

- |                       |   |
|-----------------------|---|
| (1) 94-106V/106-119V  | Refer to<br>Chapter 2 for<br>instructions |
| (2) 106-118V/118-132V |   |
| (3) 188-212V/200-225V |   |
| (4) 200-225V/212-238V |   |
| (5) 212-238V/244-251V |   |
| (6) 224-251V/235-265V |   |

Frequency: 45 to 450Hz

Power consumption: 20VA approximately

## ENVIRONMENTAL AND SAFETY SPECIFICATIONS

Operating temperature range: 0°C to +55°C

Storage temperature range: -40°C to +70°C

Humidity: 95% r.h. at +40°C

Mechanical: Tested in accordance with IEC 68  
(BS 2011 recommendations)

Safety: Meets IEC 348 (BS4743) recommendations.

## MECHANICAL

Dimensions:	Height	Width:
	83mm (case only)	240mm (case only)
	110mm overall	284mm (overall)

Depth:  
268mm

Weight: 2.7kg.

## ACCESSORIES

Accessories supplied: Operating handbook and spare fuses.

Accessories available: 19-inch rack mounting kit (11-1126)  
Rigid carrying case (15-0450)  
Padded carrying case (15-0444)  
Data output connector (23-5147)

## OPTION 01 SERIAL TO PARALLEL INTERFACE

Data and control information:	8 decades of data in 4 line BCD weighted 1248, 3 line decimal point position, print command, print hold, reset, overflow and time-base information. All logic levels TTL compatible.
-------------------------------	--

## OPTION 04A FREQUENCY STANDARD 9442

Frequency:	5 MHz.
Ageing Rate:	$\pm 3$ parts in $10^9$ /day averaged over a minimum of 10 days after 3 months continuous operation.
Warm-up Time:	Better than $\pm 2$ parts in $10^7$ within 6 minutes.
Temperature stability:	Better than $\pm 3$ parts in $10^9$ per °C averaged over the range -10°C to +45°C, but operable to +55°C.

## OPTION 04C FREQUENCY STANDARD 19-0834

Frequency:	5 MHz.
Temperature stability:	$\pm 8$ parts in $10^6$ over temperature range 0°C to +55°C. $\pm 3$ parts in $10^6$ over temperature range +20°C to +40°C.
Average ageing rate:	$\pm 1$ part in $10^6$ per month three months after delivery but less than $\pm 1$ part in $10^5$ in the first year.

## SUPPLEMENTARY DATA

### DATA OUTPUT CONNECTIONS

Data and command information is provided on a 28-way edge connector accessible via a removable cover on the rear panel. The facilities and pin connections are listed in Table 1 below. The logic for time base and function data is given in Tables 2 and 3, and supplementary information in the Appendix to this chapter.

**TABLE 1**  
**Data Output Connectors**

Pin	Facility	Pin	Facility
1	-5V (nominal)	A	0V
2	+5V (nominal)	B	Overflow *
3	Key Way	C	Key Way
4	$\overline{4}$ (BCD)	D	$\overline{1}$ (BCD)
5	$\overline{8}$ (BCD)	E	2 (BCD)
6	External Hold Input	F	10 kHz Sync.
7	External Reset Input	H	Main Gate
8	Not used	J	Not used
9	$\overline{c}$ } Function	K	$\overline{z}$ } Time Base
10	$\overline{b}$ } Information	L	$\overline{y}$ } Information
11	$\overline{a}$ } (See Table 2)	M	$\overline{x}$ } See Table 3
12	$\overline{R_0}$	N	Not used
13	Hold/Reset	P	Not used
14	Not used	R	Not used

\* The Overflow level on pin B is a static indication.

## FUNCTION AND TIMEBASE LOGIC CODES

### Function Data

Function information format : 3 lines coded as follows. The table gives the logic available at the edge connector. The inverse levels are applied to the CDI chip in the instrument.

**TABLE 2**  
**Function Information**

Function	Code		
	$\overline{a}$	$\overline{b}$	$\overline{c}$
Frequency	1	1	1
Average Period	0	1	1
Totalize $\frac{A}{n}$	0	1	0
Ratio $\frac{A}{nB}$	1	1	0
T.I. (single line or double line not averaged)	0	0	1
T.I. (single line or double line averaged)	1	0	1

### Time Base Selection Data Output

Time Base information : 3 lines coded as follows.

**TABLE 3**  
**Time Base Selection**

Code $\overline{x}$	$\overline{y}$	$\overline{z}$	Frequency Gate Time	Multiplier 'n'	Time Interval Clock
1	1	1	1 ms	1	0.1 $\mu$ s
0	1	1	10 ms	$10^2$	1 $\mu$ s
1	0	1	100 ms	$10^3$	10 $\mu$ s
0	0	1	1 sec	$10^4$	100 $\mu$ s
1	1	0	10 sec	$10^5$	1 ms
0	1	0	100 sec	$10^5$	10 ms

## APPENDIX 1

### DATA, TIME BASE AND CONTROL PRINCIPLES

#### FUNCTION AND TIME BASE CODES

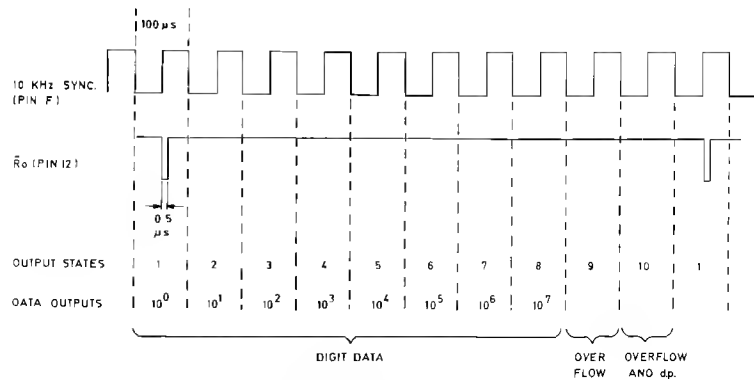
A1. The function and time base requirements are applied internally to the CDI chip on a six-line code. The inverse states of this code are fed out to the rear data output connector. The function and time base information codes are given in Tables 2 and 3 on the previous page.

#### DATA OUTPUT FORMAT

A2. In standard format the b.c.d. output data is available at the 28-way edge connector in a bit parallel byte serial form. The data is sequenced by a 10 kHz synchronising signal. The data presentation is delayed 0.5  $\mu$ s from the negative edge of the synchronising signal. An additional synchronising pulse ( $R_0$ ) determines the first state ( $10^0$  digit). Accessories are available to give data output in parallel format (for printers etc.) or IEC/ASCII bus compatible format (Options).

A3. The ten data output states are as follows: the timing is shown in Fig. 1.

States	Facility
1 to 8	Digit (display information).
9	Overflow for $10^3$ , $10^4$ , $10^6$ and $10^7$ digits on pins D, E, 4 and 5 respectively.
10	Decimal point position in kHz units, plus overflow information for $10^5$ digit, via pin 5.

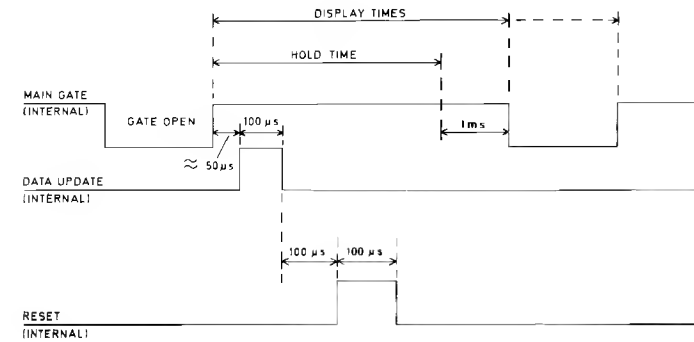


Data Sequence Diagram

Fig.1

#### INTERNAL CONTROL SEQUENCE

A4. Figure 2 shows the control sequence diagrammatically (not to scale).



Control Sequence Diagram

Fig. 2

**NOTE:** The longer display time applies to the latched modes.

#### External Hold

A5. If, when used with external circuitry, it is required to extend the cycle time, the external hold, (logic '0', pin 6) must be applied within the gate or hold time. In order to initiate a new cycle of measurement, the external hold must go 'high' for not less than 200  $\mu$ s.

#### External Reset

A6. External reset is achieved by the application of logic '0' to pin 7 of the connector for a period of not less than 5 ms; on reverting to '1' level this will reset the display to 'all zeros' and initiate a new measurement cycle.

## CHAPTER 1

### GENERAL DESCRIPTION

#### INTRODUCTION

1.1 The 9902 and 9906 are compact universal counter timers, powered from a.c. line supplies, and with a comprehensive range of facilities. The two instruments differ in that the 9902 has a frequency autoranging facility and the 9906 provides an extended (VHF) frequency range, with prescaling and reduced sensitivity above 150 MHz. In all other respects the instruments are operationally identical.

#### OPERATING FACILITIES

1.2 (a) Frequency measurement:-

'A' Channel, AC mode:	<u>9902:</u>	10 Hz - 50 MHz
	<u>9906:</u>	10 Hz - 30 MHz (HF range) 30 MHz - 200 MHz (VHF range)

'A' Channel, DC mode (both models): d.c. - 20 MHz.


'B' Channel, AC mode	<u>9902:</u>	100 Hz - 10 MHz
	<u>9906:</u>	10 Hz - 10 MHz

'B' Channel, DC mode (both models): DC - 10 MHz

On the 9902 an AUTO facility automatically selects the optimum resolution up to a one second gate time.

- (b) Period Measurement: 1 to  $10^5$  periods in decade steps, a.c. or d.c. coupled.
- (c) Ratio Measurement: Refer to Chapter 4.
- (d) Time Interval, single or double line, with manual or electrical start/stop and trigger slope selection. Fixed start delay is included to minimise the effects of contact bounce in the customer's equipment when using contacts.

- (e) Totalize will provide the total of a succession of events, using either manual or electronic start/stop signals.

NOTE: The front panel symbol  advises the user to consult the handbook for further details.

#### CHECK FACILITIES

##### 1 MHz Readout

1.3 When CHECK mode is selected the 1 MHz internal reference signal is fed through the instrument to provide an operational check on Frequency and Period modes.

##### Segment Check

1.4 With CHECK selected the instrument will display 'all eights' when the RESET button is pressed, thus checking all segments in the display i.e.d's

#### DELAY CIRCUIT

1.5 To minimise contact bounce effects on external timing, the inputs to the 'A' and 'B' amplifiers are fitted with identical delay circuits, which are selected simultaneously by a front panel switch. The circuits give a 'hold-off' to the input signal of approximately 10 ms, and are thus effective in suppressing contact bounce effects up to 50 Hz. The delay is operative on 'A' and 'B' channels (d.c. coupled) and on 'B' channel (a.c. coupled).

The delay capacitors are mounted on pins to facilitate removal, or to permit a change of value to obtain a smaller delay. For advice on external contact closure refer to para. 2.10.

#### AC (LINE) POWER SUPPLY

1.6 The instrument operates from a.c. supplies between 94 and 265 volts, 45-450 Hz. Tappings and a link on the internal line transformer provide for a choice of six voltage ranges. A rear panel switch must be set to select either the upper or lower half of the chosen range. Refer to Chapter 2 for selection instructions. A label fixed to the rear panel should indicate the selected voltage range. Spare labels are supplied with the instrument for voltage ranges other than 212 - 251V.

## FREQUENCY STANDARD

1.7 Customers are offered a choice of two high stability temperature controlled frequency standard from the Racal-Dana range, or an unovened oscillator. Details are given on pages Tech. Spec. (9). The high stability units should be serviced only by Racal-Dana or authorised agents. An aperture in the rear panel provides access for calibration of the frequency standard. A 1 MHz reference frequency, derived from the standard in use, is available from a BNC socket on the rear panel.

1.8 An external standard, which will over-ride the internal standard, can be applied via the front panel 'B' input socket for use on Frequency and Period mode. A front panel l.e.d. illuminates when the external standard is operating.

## CARRYING HANDLE

1.9 The instrument is fitted with a combined carrying handle and bench stand. To adjust the stand, press in the two handle bosses simultaneously while setting the stand to the desired position.

## MAINTENANCE

1.10 The customer is recommended to take advantage of the servicing facilities offered by Racal-Dana Instrument Ltd., and agents. A comprehensive Maintenance Manual is, however, available for purchase from Racal-Dana.

## CHAPTER 2

### PREPARATION FOR USE

#### AC SUPPLY VOLTAGE SELECTION

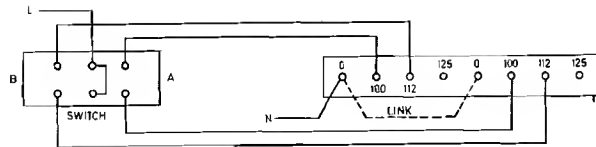
##### Introduction

2.1 A label on the rear panel shows the voltage range to which the instrument is set. Six pairs of voltage ranges are obtainable by appropriate arrangement of a link and tappings on the transformer tag board. A two-position slide switch on the rear panel enables the user to select either the upper or lower range from each pair (see Fig. 3a and 3b).

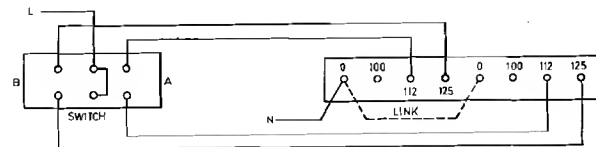
2.2 When the selection procedure has been completed, a label showing the selected range pair must be affixed to the rear panel. Instruments are manufactured with a permanent panel marking for the 212-251V range. Five spare labels are supplied in the accessories bag for use if another voltage range has to be selected.

##### Voltage Selection Procedure

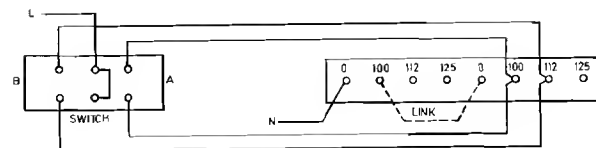
- 2.3
- (1) Unplug the power cable from the supply and remove the top cover (para. 2.9).
  - (2) Refer to Fig. 3a or Fig. 3b and note the diagram which corresponds to desired voltage range. Note that the switch diagram is drawn as seen from within the unit.
  - (3) Remove the snap-on plastic cover plate from the transformer tag board. (It clips on at the corners).
  - (4) Using a soldering iron, arrange the link and switch leads on the transformer tag board to conform with the chosen diagram. Do not disturb the neutral lead, which remains on the 0V tag at all times.
  - (5) Refit the plastic plate to the tag board.
  - (6) On the outer face of the rear panel set the switch to the position for the required upper or lower half of the voltage range, and attach the appropriate voltage label to the panel.
  - (7) Carefully recheck the work against the diagram, then replace the top cover.



94-106V (SWITCH TO 'A')  
106-119V (SWITCH TO 'B')



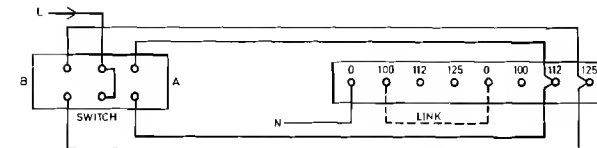
106-119V (SWITCH TO 'A')  
118-132V (SWITCH TO 'B')



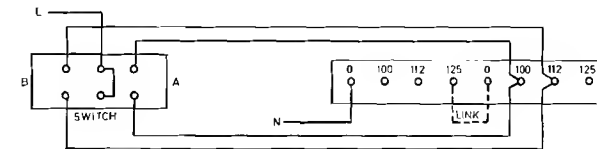
188-212V (SWITCH TO 'A')  
200-225V (SWITCH TO 'B')

Line Voltage Selection  
(CONTINUED ON FIG. 3b)

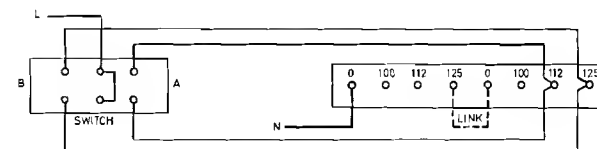
Fig. 3a



200-225V (SWITCH TO 'A')  
212-238V (SWITCH TO 'B')



212-238V (SWITCH TO 'A')  
226-251V (SWITCH TO 'B')



224-251V (SWITCH TO 'A')  
235-265V (SWITCH TO 'B')

Line Voltage Selection

Fig. 3b

## POWER FUSE

- 2.4 Check that the power fuse on the rear panel is correctly rated for the supply voltage, as follows. The fuse is a glass cartridge type, 5 x 20 mm.

Supply Range	Fuse Rating	R-D Part No.
188V - 265V	100mA anti-surge	23-0033
94V - 132V	200mA anti-surge	23-0027

## LINE CORD

- 2.5 Fit a suitable plug to the line cord in accordance with the appropriate colour code:-

Connection	European	U.S.A.
Line	Brown	Black
Neutral	Blue	White
Earth/Ground	Green/Yellow	Green

## SELF CHECK

- 2.6
- (1) Connect the a.c. supply.
  - (2) Set the POWER switch to ON.
  - (3) Set the CHECK/OPERATE/HOLD switch to CHECK.
  - (4) Depress the FREQ. 'A' MAN button (9902) or the HF button (9906) and verify that the GATE indicator illuminates.
  - (5) With  $n = 1$  selected the instrument should read 1000kHz. Refer to Table 4 and check the display and decimal points (Freq. column) for each of the 'n' range buttons.
  - (6) Depress the PERIOD 'A' button and verify the readout and decimal points according to the Period column of Table 4.
  - (7) Briefly hold in the RESET button and check that the display reads 'all eights' (segment check).

TABLE 4

## SELF CHECK READOUT

Range 'n' Selected	Gate Time	Display ( $\pm 1$ count)			
		Frequency		Period	
		9902	9906	9902	9906
1	1 ms	001000.	00001000.	000001.	As 9902 but
$10^1$	10 ms	01000.0	0001000.0	00001.0	two additional
$10^2$	100 ms	1000.00	001000.00	0001.00	'0's at left
$10^3$	1 sec	*000.000	01000.000	001.000	hand end.
$10^4$	10 sec	*00.0000	1000.0000	01.0000	
$10^5$	100 sec	*0.00000	*000.00000	1.00000	

## NOTE:

- With readouts marked (\*) the most significant digit will overflow and the OVERFLOW lamp will illuminate after the appropriate gate time.
- (8) 9902 Only. Depress the FREQ AUTO button and verify that display reads 1000.00. This checks that the AUTO facility has selected the optimum time base range ( $10^2$ ) for the 1 MHz signal.
  - (9) Finally set the CHECK/OPERATE/HOLD switch to OPERATE in readiness for normal use.

## CONNECTION OF EXTERNAL FREQUENCY STANDARD AND 1 MHz OUTPUT

- 2.7 The requirements for the external reference frequency source are given in the Technical Specification. It should be borne in mind that the accuracy of measurement is directly related to the accuracy of the frequency standard used.
- 2.8 The connection for the external frequency standard is the front panel 'B' input socket, as this socket is not used for measurement in Frequency and Period modes. When the frequency standard signal is applied, the instrument will automatically change to external standard operation. The 1 MHz reference output is available via the BNC socket on the rear panel.

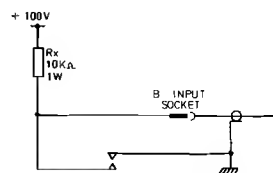
## REMOVAL OF COVERS

**WARNING:** DANGEROUS AC VOLTAGES ARE EXPOSED WHEN COVERS ARE REMOVED WITH AC SUPPLY CONNECTED.

- 2.9
- (1) Set the POWER switch to 'off', switch off the a.c. supply at the supply point and unplug the power lead.
  - (2) Remove the rubber plugs (located near to the rear end) from both side panels of the instrument and slacken, by about two turns, the screws revealed.
  - (3) Grip the rear panel assembly and ease it back from the main case to the maximum extent available (about 5 mm).
  - (4) The rear edge of either cover can now be lifted and the cover withdrawn outwards and rearwards.
  - (5) To replace the covers reverse the above procedure.

## CONTACT CLOSURE OPERATION

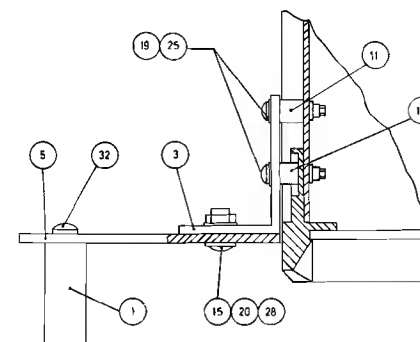
2.10 Contact closure operates in DC mode and uses the 'B' input socket for timing and the 'A' input socket for totalizing. An external current source with a sink of 0.5mA must be provided by the user. With the DELAY switch to IN, contact bounce suppression of up to 10ms is provided internally. A typical contact closure arrangement for up to +100V supply is illustrated below.



Contact Closure Supply Fig. 4

## FITTING RACK MOUNTING KIT (OPTION) TYPE 11-1126

- 2.11
- (1) Remove the bench type handle assembly by carefully prising off the plastic caps from the handle pivots, and then extracting the screws which secure the assembly to the unit. Store safely for possible future use.
  - (2) Remove the rubber bungs referred to in 'removal of covers' procedure and completely remove the two screws revealed. This allows the rear panel to be drawn away from the side panels (as far as wiring permits).
  - (3) With the rear panel drawn backwards, slide out the trim strips from the side panels. Store them safely for possible future use. Then refit the rear panel and secure firmly with the two screws removed in (2).
  - (4) At the front of the instrument, remove the screw securing the front panel on one side and discard. Refer to diagram below and fit bracket (item 3) using spacers (items 10 and 11) screws (item 25) and washers (item 19).
  - (5) Repeat (4) on the other side of the front panel.
  - (6) Fit the rack type handles (item 1) to the plates (item 5) using two Taptite screws (item 32) to each handle.
  - (7) Fit the plate assemblies to brackets on the unit, using two of items 15, 20 and 28 to each plate assembly.



Plan View: Rack Mounting 11-1126 Fig. 5



## CHAPTER 3

### DESCRIPTION OF CONTROLS

#### INDICATORS AND CONNECTIONS

Function Push-Button Switch Bank: This bank of seven push button switches, located near the centre of the front panel, select the following measurement modes:-

(i) T.I.

Provides time interval measurement between two successive events. The events may be on one line (B-B) or separate lines (B-A), with start and stop slopes of the same or opposite polarity.

(ii) T.I.Avg.

This mode is suitable for the measurement of short repetitive events, with start/stop controls as in T.I. By averaging over a number of events the resolution is increased.

(iii) FREQ. 'A'

Provides frequency measurement of the 'A' channel input with readout in kHz.

#### 9902 AUTO and MANUAL Modes

With the MAN (manual) switch depressed, the required gate time can be selected from the Range ('n') buttons. With the AUTO switch depressed, the instrument will automatically select the gate time (.01, 0.1 or 1 second) which gives optimum resolution on the display.

Function Push-Button Switch Bank (Cont'd.):

#### 9906 VHF and HF Modes

The AUTO/MANUAL facility is not fitted. Instead, these switches are marked VHF and HF, and serve as frequency range selectors. With HF selected the 'A' input range is 10Hz to 30MHz, directly gated. With VHF selected the 'A' range is 30MHz to 200MHz, prescaled by 4, but with direct readout of the measured frequency.

(iv) PERIOD 'A'

Provides period measurement on 'A' channel signal with readout in microseconds.

(v) RATIO  $n \frac{A}{B}$

Refer to Chapter 4, para. 4.9.

(vi) TOTAL  $\frac{A}{n}$

Provides accumulated total of events applied to Channel 'A', with prescaling by the factor 'n' according to the switch selected in the Timebase switch bank.

Timebase Range Push-Buttons:

This bank of six 'n' switches offer a choice of gate times. The multiplier 'n' associated with each switch may also be defined as follows:-

(a) The number of periods averaged on 'period average' measurement.

(b) The 'A' input prescale factor on 'totalise'.

(c) The 'B' input prescale factor on 'ratio'.

(d) The number of intervals averaged on 'time interval average'.

(e) The switch bank also is used to select the clock unit on 'time interval'.

**START Slope Switch:** A slide switch which selects either positive-going or negative-going trigger edge for start of time interval, time interval average, and totalize measurements. Applies to the 'B' channel only.

**STOP Slope Switch:** Selects the required 'stop' trigger edge polarity on time interval, time interval average, and totalize.

**DELAY IN/OUT Switch** When measuring time intervals with external start and stop contacts, contact bounce effects can be suppressed by setting the DELAY switch to IN. This holds off any stop signal for approximately 10ms. The control is operative with the a.c. and d.c. amplifiers of channel 'B' and the d.c. amplifier of channel 'A'.

**B-B/B-A Switch** Position B-B selects single line 'start/stop' for time interval measurement (Channel 'B'). Position B-A selects 'start' Channel 'B' and 'stop' Channel 'A' on time interval measurements.

**AC/DC Switches** These switches select either a.c. or d.c. coupling in the input amplifiers.

#### Operation on DC Mode

The use of d.c. mode is recommended in the following circumstances:-

- (a) For signals having a slow rate of rise and fall (e.g. sinusoidal signals of frequency lower than 10 Hz).
- (b) For signals of rectangular waveform which have a mark/space ratio other than 1:1, provided the frequency is less than 10 MHz.

#### **CHECK/OPERATE/HOLD Switch:**

OPERATE is normal setting. CHECK provides a 1 MHz readout of the internal reference frequency (on Frequency and Period) for self-check of counting and display circuits. In the HOLD position the display is held, but a single shot update can be obtained by depressing and releasing the adjacent RESET button.

#### Segment Check

To check all LED segments in the display, press the RESET button while in CHECK mode. This will produce an 'all 8' display.

#### **START/STOP Push-Button:**

Provides manual start/stop on Time Interval and Totalize modes.

#### **RESET Push-Button:**

When the RESET button is depressed and released the instrument will clear down to zero and initiate a new measurement. The RESET button is also used in the segment check.

#### **AC SENSITIVITY Control:**

This is a potentiometer providing manual variation of sensitivity in the 'A' input when the AC/DC switch is set to AC. The most sensitive position is fully anticlockwise. The control is also useful in filtering out h.f. interference on lower frequency measurements.

#### **POWER ON/OFF Switch:**

Switches off the a.c. supply to the line power transformer.

#### INDICATORS

##### **OVERFLOW:**

The OVERFLOW indicator will illuminate when the count exceeds the capacity of the display.

##### **GATE:**

The GATE indicator illuminates when the counter gate is 'open'. Thus the illumination period is related to gate time selected.

EXTERNAL STANDARD:

The l.e.d. illuminates when the external standard is connected and operating.

UNITS INDICATORS:

In the 9906 four l.e.d.'s provide appropriate indication to show the units for interpreting the display - kHz/ $\mu$ s, ms, ns and seconds.

REAR PANEL ITEMS

1 MHz O/P Socket:

A 1 MHz reference signal derived from the frequency standard in use is available at this BNC socket.

Data Output Connector:

The facilities provided by the 28-way edge connector are listed in Table 1 on page Tech.Spec. (10).

Power Plug/Filter:

A three-core power lead (line cord) is supplied with the instrument.

Power Fuse:

Fuse ratings are marked on the rear panel. A surge resisting 5 x 20mm type must be used.

Osc. Adjust:

This aperture provides access to the colibration adjustment in the 5 MHz reference oscillator. Colibration must be carried out in accordance with instructions in the maintenance manual.

Voltage Selector Switch:

This switch is set in conjunction with selectedappings on the line power transformer. Instructions are given in Chapter 2. It is important that the label adjacent to the switch shows the voltage range selected.

CHAPTER 4

OPERATING INSTRUCTIONS

POWER SUPPLY

4.1 Before operating a new instrument, or at a new location, check that the line voltage selection is correct (check rear panel label) and that the fuse has the specified rating.

FREQUENCY MEASUREMENT

4.2 In this mode the unknown frequency is gated to the counter decades for the gating period selected by the chosen Timebase push-button (n). For frequencies below 10kHz the use of period mode will give greater resolution.

- (1) Set the POWER switch to ON.
- (2) Set the following controls:-
  - (a) Function switch to FREQUENCY - 'A' MAN. (9902) or, on the 9906, select required range, VHF or HF.
  - (b) The 'A' channel AC/DC switch to AC or DC, as required.
  - (c) If using AC mode set the SENSITIVITY control initially to the maximum clockwise position.
  - (d) CHECK/OPERATE/HOLD switch to OPERATE.
  - (e) DELAY switch to OUT.
- (3) Connect the unknown signal to the 'A' input socket.
- (4) If counting is not satisfactory adjust the SENSITIVITY control anti-clockwise towards the 10mV setting until a stable reading is obtained.
- (5) Select the 'n' push-button which fills the display, or switch to AUTO (9902 only) for optimum resolution. The frequency readout is in kHz.

- (6) If operating on HOLD, press and release the RESET button to obtain a new reading.

### PERIOD MEASUREMENT

4.3 This mode is recommended for measuring low frequencies in the range 1Hz to 10kHz with improved resolution. The incoming unknown signal is taken to the timebase decade dividers, the output of which (selected by the timebase push-buttons) is used to gate the internal frequency standard to the counter decades. The display indicates the actual value of the period of the incoming signal in microseconds. Greater accuracy is obtained by selecting a longer gate time, thus taking the measurement over a greater number of periods.

#### Period Operation

- 4.4 (1) Set the POWER switch to ON.
- (2) Set the following controls:-
- (a) Function switch to PERIOD 'A'.
  - (b) The 'A' channel AC/DC switch to AC or DC, as required.
  - (c) If using AC mode, set the SENSITIVITY control initially to maximum clockwise.
  - (d) CHECK/OPERATE/HOLD switch to OPERATE.
  - (e) DELAY switch to OUT.
- (3) Connect the unknown signal to the 'A' input socket.
- (4) Select the number of periods to be timed, by depressing the relevant Timebase push-button. A greater number of periods gives increased resolution, but longer measuring time.
- (5) Adjust the SENSITIVITY control anticlockwise to obtain steady counting. This control is useful in filtering out h.f. interference on low frequency measurements.
- (6) If operating on HOLD press and release the RESET button to obtain a new reading.

### TIME INTERVAL (T.I. and T.I. Average)

- 4.5 In this mode the instrument is effectively serving as a stop watch by counting clock pulses derived from the frequency standard. The time interval may be controlled by successive events on a single line (such as pulse widths) in which case Input 'B' is used with the B-B/B-A switch set to B-B.
- 4.6 For timing events on separate lines the B-B/B-A switch must be set to B-A. The 'start' signal applied to the 'B' input and the 'stop' signal to the 'A' input. Trigger slopes can be selected by the START/STOP slope switches.
- 4.7 The T.I. mode is most suited to the measurement of single intervals such as pulse widths. A range of widths from 100 ns to several hours may be measured by selecting the appropriate clock unit. The maximum clock rate is 100 ns, therefore resolution on short duration pulses is likely to be unsatisfactory, but can be improved by the use of T.I. Average mode, which increases resolution by the averaging of the inherent  $\pm 1$  count 'gate uncertainty' factor over a number of time intervals (1 to  $10^5$ ). It should be noted, when time averaging, that the repetition rate of the pulses under measurement must not be harmonically related to the frequency standard in use.

NOTE: On Time Interval Average (single line) the  $\overline{\text{L}}$  to  $\overline{\text{L}}$  and  $\overline{\text{L}}$  to  $\overline{\text{L}}$  measurement is effectively equivalent to Period mode. Therefore the user is recommended to use Period for this particular type of measurement as the accuracy is greater and the measurement time reduced.

#### Time Interval Operation

- 4.8 (1) Set the POWER switch to ON.
- (2) Set the following controls:-
- (a) Function: depress the required T.I. or T.I. Avg. button (see NOTE above).
  - (b) CHECK/OPERATE/HOLD switch to OPERATE
  - (c) B-B/B-A switch: for single line select B-B. For double line select B-A, and AC/DC switch to DC.
  - (d) Set the AC/DC switches as required.
  - (e) START and STOP slope switches: select required triggering polarities (not required for manual timing).
  - (f) DELAY switch to IN if contact bounce suppression is required.

- (3) Connect the input(s) for electronic timing. For single line timing connect the external signals to Input 'B'. For double line connect the 'start' line to 'B' and the 'stop' line to 'A'.
- (4) Press the Timebase (n) button which provides the appropriate readout. In the 9906 an l.e.d. will indicate the units of the display.
- (5) For manual timing press the START/STOP push-button, as required.
- (6) If operating on HOLD press and release the RESET button to initiate a new (non-manual) timing process.

$$\text{RATIO } n \frac{A}{B}$$

4.9 In this mode, two unknown signals are fed to inputs 'A' and 'B'. Generally the higher frequency is fed via input socket 'A' to the counter decades and the lower frequency is fed through input socket 'B' to the time-base decades, but this input arrangement may be reversed, as for example, when the lower frequency has a smaller amplitude (e.g. 10 mV) and the higher frequency a considerably larger amplitude. The display indicates the ratio  $n \frac{A}{B}$  and the reading must be divided by the factor 'n' to obtain the ratio  $n \frac{A}{B}$ .

#### Ratio Operation

- 4.10 (1) Set the POWER switch to ON.
- (2) Set the following controls:-
  - (a) The FUNCTION switch to RATIO  $n \frac{A}{B}$ .
  - (b) The AC/DC switches to AC or DC as appropriate.
  - (c) CHECK/OPERATE/HOLD switch to OPERATE.
  - (d) DELAY switch to OUT.
- (3) Connect the input signals to sockets 'A' and 'B'. (See para. 4.9 above).
- (4) Press the Timebase (n) button which gives a full display without overspill.
- (5) If on AC adjust the SENSITIVITY control as necessary.

- (6) If on HOLD press the RESET button for a new reading.
- (7) To obtain the true ratio the displayed reading must be divided by the factor 'n' indicated above the selected Timebase button.

$$\text{TOTALIZE } \frac{A}{n}$$

4.11 In this mode, signals on input socket 'A' are prescaled and taken to the counter decades. The count can be controlled manually by the START/STOP button, or electrically by timing signals connected to socket 'B'. This mode permits a number of events occurring with random timing to be counted over a chosen period.

- (1) Set the POWER switch to ON and other controls as follows:-
    - (a) The Function switch to TOTAL  $\frac{A}{n}$ .
    - (b) The 'A' channel AC/DC switch as required.
    - (c) The CHECK/OPERATE/HOLD switch to OPERATE.
    - (d) The DELAY switch as required.
    - (e) The START and STOP slope switches to select the required trigger edge polarities.
  - (2) Connect the signal to be totalized to socket 'A' and the electrical timing signals (if used) to socket 'B'.
  - (3) Press the Range push-button which will provide suitable units for the count. For example, if the  $10^3$  button is depressed the display will be in units of 1000 (within the accuracy of measurement).
- NOTE: If the range  $n = 1$  is used a count of 1 will be displayed when the main gate opens.
- (4) If operating on HOLD, press and release the RESET button before taking a reading.
  - (5) If manual control is being used press the START/STOP button to commence counting and again to terminate counting. The display will be held for about four seconds before automatically clearing.
  - (6) In order to obtain the true total the displayed reading must be multiplied by the scaling factor 'n' indicated above the selected Range button.